

Title: **COPPER CONDUCTORS USED
FOR EARTHING IN
SUBSTATIONS**

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1. Introduction

This standard is intended to ensure that the copper conductors used for earthing in substations are correctly specified to meet the desired performance requirements at Eskom substations.

2. Supporting clauses

2.1 Scope

This standard covers the Eskom-specific technical requirements for copper earthing conductors for use in substations. The copper earthing conductors specified must fully comply with the minimum requirements set out in the relevant standards referenced.

2.1.1 Purpose

To standardise Eskom’s specific technical requirements for copper earthing conductors for use in substations and to reference applicable SANS standards.

2.1.2 Applicability

This document shall apply throughout Eskom Holdings Limited Divisions.

2.2 Normative/Informative references

Parties using this document shall apply the most recent edition of the documents listed in the following paragraphs.

2.2.1 Normative

- [1] BS EN 13601, Copper and copper alloys – Copper rod, bar, and wire for general electrical purposes
- [2] D-DT-6044, BAR:ROUND;DIA 10 MM;CU;ANNEALED
- [3] D-DT-6045, STRIP:FLAT;WD 50 MM;THK 3.15 MM;CU
- [4] ISO 9001, Quality Management Systems
- [5] SANS 804:2008, Unwrought tough pitch coppers: Electrolytic tough pitch high conductivity copper
- [6] SANS 1195:2010, Busbars
- [7] SANS 5544:2008, Dimensions of aluminium and copper strip, sheet, rod, bar, tube, channel and angle

2.2.2 Informative

None

2.3 Definitions

2.3.1 General

Definition	Description
Conductivity	A material’s ability to conduct electric current. It is the inverse of its volume resistivity. Expressed as “Siemens per metre.”

Definition	Description
International Annealed Copper Standard	An empirically derived standard value for the electrical conductivity of commercially available copper established in 1914 by the United States Department of Commerce and adopted by the IEC. For annealed copper: Conductivity: 58×10^6 S/m at 20 °C Volume resistivity: $17,241 \times 10^{-9}$ ohm·m at 20 °C Mass resistivity: 0,15328 ohm (metre, gram) at 20 °C
Mass resistivity	The product of the electrical resistance of a conductor and its mass, divided by the square of its length; or the product of the electrical resistivity and the density. Expressed as “ohm (metre, gram).”
Volume resistivity	The product of the electrical resistance of a conductor and its cross-sectional area, divided by its length (normally 1 metre). Expressed as “ohm (metre, mm ²)” or “ohm·m.”

2.3.2 Disclosure classification

Controlled disclosure: controlled disclosure to external parties (either enforced by law, or discretionary).

2.4 Abbreviations

Abbreviation	Description
$\Omega \cdot m$	ohm metre
°C	degree Celsius
Cu	Copper
ETP	Electrolytic Tough Pitch
g	gram
IACS	International Annealed Copper Standard
IEC	International Electrotechnical Commission
m	metre
mm	millimetre
MS/m	mega Siemens per metre
nΩ·m	nano ohm metre
S/m	Siemens per metre
SANS	South African National Standard
UM	Unit of Measure

2.5 Roles and responsibilities

All employees that specify and technically evaluate copper earthing conductors for installation in substation applications shall adhere to this standard during tender and/or technical evaluation activities.

2.6 Process for monitoring

Not applicable.

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2.7 Related/Supporting documents

Not applicable.

3. Copper earthing conductor requirements

This section covers the requirements with which the copper earthing conductors shall comply.

3.1 Conductor technical requirements

All copper conductors for use in substation earthing systems shall comply with the specifications stipulated in this section.

3.1.1 Material

The material used, its chemical composition, and condition of temper shall be as stipulated below:

- Cu-ETP (high conductivity copper) in accordance with [5] or
- Cu-ETP (CW004A) in accordance with [1].

The condition of temper shall be annealed.

The material offered shall comply with the chemical composition as stipulated in Table 1, to be verified by a chemical composition test report.

Table 1: Material chemical composition

	Composition % (mass fraction)
Copper (Cu)	≥ 99,9
Bismuth (Bi)	≤ 0,001
Lead (Pb)	≤ 0,005
Total of all impurities (excluding oxygen)	≤ 0,03

3.1.2 Electrical properties

The conductors shall comply with the electrical properties as stipulated in Table 2. The tested electrical properties shall be stated in Technical Schedule B and must be supported by the submitted test reports.

Table 2: Material electrical properties at 20 °C

	UM	Electrical properties at 20 °C
Equivalent conductivity	% IACS	≥ 100
Conductivity	MS/m	≥ 58
Volume resistivity	nΩ·m	≤ 17,24
Mass resistivity	ohm (metre, gram)	≤ 0,1544

3.1.3 Dimensional requirements

The dimensions of the conductors offered shall comply with the dimension specification as stipulated in Table 3 Column 6. Actual measured dimensions shall be stated in Technical Schedule B and must be supported by the submitted test report as listed in Annex C.

Eskom has adopted the two items listed in Table 3 with standard dimensions in accordance with [6].

Table 3: Copper earthing conductors for use in Eskom

1	2	3	4	5	6
Conductor	D-DT	SAP number	UM	SAP description	Dimension specification
1	6044	0400769	kg	BAR: ROUND; DIA 10 MM; CU; ANNEALED	Nominal diameter: 10 mm ±0,05 mm (as stipulated in [6] Table 3)
2	6045	0400772	kg	STRIP: FLAT; WD 50 MM; THK 3.15 MM; CU	Nominal width: 50 mm ± 0,30 mm Nominal thickness: 3,15 mm ± 0,15 mm (as stipulated in [6] Table 1)

3.2 Packaging and marking

3.2.1 Packaging

All conductors shall be supplied coiled in rolls not weighing more than 45 kg ± 0,5 kg. Taking the density of copper as 8,89 g/cm³ (from [1] and IEC 600028) the following is applicable at nominal coil weight and conductor dimensions:

- Item 1: BAR: ROUND; DIA 10 MM; CU; ANNEALED shall be 64,45 m per roll (0,698 kg/m)
- Item 2: STRIP: FLAT; WD 50 MM; THK 3,15 MM; CU shall be 32,14 m per roll (1,400 kg/m)

3.2.2 Marking

As specified in [6], each coil shall bear the following information legibly and indelibly marked on a label that is securely attached to the package:

- The manufacturer's name or trade name or trademark (or any combination of these);
- A description of the contents that includes the type of material, temper, form, and cross-sectional dimensions; and
- The net mass of the contents in kilograms.

3.3 Tests

As a minimum, all suppliers shall comply with all test requirements stated in this document.

All testing shall be done by an independent testing laboratory or witnessed by an independent testing authority if done in-house.

3.3.1 Test certificates and reports

Copies of the stipulated test reports and certificates shall be submitted to Eskom in electronic format at the tender stage. As a minimum, test reports shall contain the following information:

Name and address of test facility and the independent testing authority that witnessed the test if it was done in-house.

- Contact details of the test facility and the independent testing authority that witnessed the test if it was done in-house.
- Details and validity of accreditation of test facility or the independent testing authority that witnessed the test if it was done in-house.
- Date of test.
- Type of test.
- Test procedure to which test was conducted.

- Test results.
- Analysis of test results, a statement that the conductor conforms or does not conform to stipulated requirements.
- Names and titles of personnel who conducted and witnessed the test if the test was done in-house.

3.3.2 Material composition

The material composition shall be tested to verify the chemical composition compliance listed in Table 1.

3.3.3 Electrical properties

The electrical resistivity of the conductors shall be determined by direct measurement as stipulated in IEC60028 or IEC60468 to verify compliance with the requirements listed in Table 2.

3.3.4 Dimensions

The conductor dimensions shall be tested as stipulated in [7] and must comply with the requirements stated in Table 3, Column 6.

3.4 Returnables to be submitted as part of a tender

The following shall be submitted as returnables during the tender enquiry:

- Completed Technical Schedule B, refer to Annex A.
- Deviations and Declarations report, refer to Annex B.
- Type Test Schedule, refer to Annex C.
- Test certificates and reports in accordance with Section 3.3:
 - Material composition
 - Electrical properties
 - Material dimensions
- Sample label in accordance with 3.2.2.

4. Authorisation

This document has been seen and accepted by:

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5. Revisions

Date	Rev	Compiler	Remarks
Sept 2020	1	TJ Marais	First issue

6. Development team

The following people were involved in the development of this document:

- Mohamed Khan - Senior Engineer, Design and Standards Implementation, KZN OU
- Shamona Sivasamy - Senior Engineer, Design and Standards Implementation, M OU
- Theunus Marais - Chief Engineer, Substation Engineering, Operations Support

7. Acknowledgements

Johan Ackerman, Johan Mostert, and Richard Krusekopf for inputs and advice.

Annex A – Technical Schedules A and B

This section must be read together with Section 3 of this document.

Schedule A: Eskom’s particulars requirements

Schedule B: Technical particulars of conductor offered based on test report results

A separate technical schedule shall be completed per conductor. Select the appropriate conductor from the table below.

CONDUCTOR	D-DT	SAP No	SAP DESCRIPTION	SELECT ITEM
1	6044	0400769	BAR: ROUND; DIA 10 MM; CU; ANNEALED	
2	6045	0400772	STRIP: FLAT; WD 50 MM; THK 3.15 MM; CU	

ITEM	DESCRIPTION	SCHEDULE B
1	Manufacturer’s details	
1.1	Manufacturer	
1.2	Manufacturer’s local agent/supplier	
1.3	Manufacturer’s material type reference	

ITEM	DESCRIPTION	UNIT	SCHEDULE A	SCHEDULE B
2	Material			
2.1	Material		Copper	
2.2	Designation		Cu-ETP	
2.3	Condition of temper		Annealed	
2.4	Chemical composition:			
	Copper (Cu)	%	≥ 99,9	
	Bismuth (Bi)	%	≤ 0,001	
	Lead (Pb)	%	≤ 0,005	
	Total of all other impurities	%	≤ 0,03	
3	Electrical properties at 20 °C			
3.1	Equivalent conductivity	% IACS	≥ 100	
	or Conductivity	MS/m	≥ 58	
	or Volume resistivity	nΩ·m	≤ 17,24	
	or Mass resistivity	Ω (m, g)	≤ 0,1544	

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ITEM	DESCRIPTION	UNIT	SCHEDULE A	SCHEDULE B
4	Dimensions			
4.1	Nominal dimension(s)	mm	As specified	
4.2	Specific dimension(s)	mm	From test report	
5	Test reports			
5.1	Material composition and temper test report		Mandatory	
5.2	Electrical resistivity/conductivity test report		Mandatory	
5.3	Dimensional tolerances test report		Mandatory	
6	Product label			
6.1	Provide sample of product label		Mandatory	

Annex B – Deviations and Declarations

The following must be noted:

- 1) All deviations to any requirement in this technical schedule and associated specification must be listed below with clear explanations/justification.
- 2) All documents to be provided in hard copy in addition to any soft copies offered, in accordance with tender requirements.
- 3) If no deviations/modifications/alternatives are offered, this schedule must be marked N/a and signed.

SPECIFICATION/ SCHEDULE PAGE NUMBER	SPECIFICATION/ SCHEDULE CLAUSE NUMBER	PROPOSED ALTERNATIVES	DEVIATIONS/MODIFICATIONS/

Declaration by supplier:

With the exception of the above deviations, this specification, associated technical schedules, factory evaluation, and annexures together with the requirements contained within, will be fully complied with in the manufacture, testing, supply, provision of drawing and documents, packaging, labelling, transport, and delivery of the product being offered, amongst others. Further, it is declared that all information provided has been checked and is correct.

Full name of authorised representative: _____

Designation of authorised representative: _____

Signature: _____

Date: _____

Annex C – Type Test Schedule

The following must be noted:

- 1) This section must be read together with Section 3.3 of this document.
- 2) A separate type test schedule shall be completed per conductor. Select the appropriate conductor from the table below.
- 3) List all the type test report numbers applicable.

CONDUCTOR	D-DT	SAP No	SAP DESCRIPTION	SELECT ITEM
1	6044	0400769	BAR: ROUND; DIA 10 MM; CU; ANNEALED	
2	6045	0400772	STRIP: FLAT; WD 50 MM; THK 3.15 MM; CU	

ITEM	CLAUSE	DESCRIPTION	REPORT NO.
1	3.3.2	Material composition and temper test report	
2	3.3.3	Electrical resistivity/conductivity test report	
3	3.3.4	Dimensional tolerances test report	